(57)Abstract:
PURPOSE: To obtain a small-sized velocity meter, which can be mass-produced at low
cost, by forming a vibrator in the shape of a beam supported on both ends by a base
body.
CONSTITUTION: A lower electrode 4 is divided into an electrode 9 for driving and
electrodes 8a, 8b for detection. When an upper electrode 6 is used as a common ground
and an electric field having frequency close to the cantilever natural frequency of a
vibrator 1 is applied to the electrode 9, cantilever vibrations are excited in the direction
of V by the vibrations of a PZT piezoelectric film 5. When the vibrator 1 is moved in
the direction V at velocity V, Coriolis force Fc works on the vibrator 1 when rotational
angular velocity Ω is applied around the axis of a cantilever in the axial direction of the
cantilever. The force deflects the vibrator 1 in the direction perpendicular to the
direction of vibrations. When force is applied in the directions of Ω and Fc, compressive
stress works on the electrode 8a side and tensile stress to the electrode 8b side. When
voltage between the electrode 8a and a ground is represented by Va and voltage

between the electrode 8b and the ground by Vb, a signal resulting from cantilever vibrations is offset in a signal by Coriolis force when difference Va-V2b of both voltage is taken, and only the signal by Coriolis force can be read.

CLAIMS

[Claim(s)]
[Claim 1] The piezo-electric oscillating angular-velocity meter characterized by having the doubly-supported beam configuration in which said vibrator was supported by said base in the piezo-electric oscillating angular-velocity meter which consists of a base which supports the vibrator and it which were formed of the silicon processing process, and a thin film which consists of the piezo-electricity and/or electrostriction ingredient which were formed through direct or other layers on said vibrator.
[Claim 2] The piezo-electric oscillating angular-velocity meter characterized by having the cantilever configuration in which said vibrator was supported by said base in the piezo-electric oscillating angular-velocity meter which consists of a base which supports

the vibrator and it which were formed of the silicon processing process, and a thin film which consists of the piezo-electricity and/or electrostriction ingredient which were formed through direct or other layers on said vibrator.

[Claim 3] The piezo-electric oscillating angular-velocity meter characterized by forming in both sides of this thin film at parallel the thin film which consists of said piezo-electricity and/or an electrostriction ingredient on said vibrator with an electrode in a piezo-electric oscillating angular-velocity meter according to claim 1 or 2.

[Claim 4] The piezo-electric oscillating angular-velocity meter characterized by detecting the piezo-electric signal which divides into two at the symmetry one [at least] electrode of the electrode formed in both sides of said thin film to the shaft of a beam in a piezo-electric oscillating angular-velocity meter according to claim 3, takes the difference of the signal acquired from two electrodes, and originates in Coriolis force.

[Claim 5] The piezo-electric oscillating angular-velocity meter characterized by to detect the piezo-electric signal which trichotomizes into the symmetry one [at least] electrode of the electrode formed in both sides of said thin film to the shaft of a beam in a piezo-electric oscillating angular-velocity meter according to claim 3, takes the difference of the signal which carries out the central polar zone to detection, and is acquired [polar zone] from both the detection electrode in the polar zone of the object for actuation, and both sides, and originates in Coriolis force.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the piezo-electric oscillating angular-velocity meter which detects the angular rate of rotation of an oscillation using the piezo-electric effect of forward and reverse. It is related with the piezo-electric oscillating angular-velocity meter which can be mass-produced especially that it is small and cheaply.

[0002]

[Description of the Prior Art] With forward and the piezo-electric oscillating angular-velocity plan using the piezo-electric effect of reverse, GE type and the WATOSON type were in use two kinds conventionally. With a piezo-electric GE type oscillating angular-velocity plan, while an electrostrictive ceramics plate is pasted up on the cylindrical vibrator made with the metal as shown in drawing 3 , and this drives metal vibrator, the Coriolis force produced with a revolution of vibrator is detected. By non-restrained transverse oscillation, the mode of the oscillation used usually fixes an

oscillation to a base in the joint of an oscillation.

[0003] With a WATOSON type piezo-electricity oscillating angular-velocity plan, as shown in <u>drawing 4</u>, the piezo-electric ceramic bimorph of four sheets is piled up so that two sheets may intersect perpendicularly at a time mutually, and it considers as a tuning fork configuration, the whole tuning fork is excited by the bimorph for actuation, and the Coriolis force produced with the revolution of a component is detected by the bimorph for detection. These components are applied as an angular-velocity sensor, a hand deflection sensor, etc., and have many track records.

[0004]

[Problem(s) to be Solved by the Invention] However, these piezo-electric oscillating angular-velocity meters had the complicated approach of the configuration of vibrator, and immobilization, and since the complicated processes, such as adhesion of a ceramic plate and mounting of lead wire, were indispensable, it was impossible to have performed miniaturization and low cost-ization. The object of this invention solves these problems and is to offer the piezo-electric oscillating angular-velocity meter which it can be small and can be mass-produced cheaply.

[0005]

[Means for Solving the Problem] This invention a silicon processing process and the vapor phase synthetic method of the piezo-electricity and electrostriction ingredient which prospered recently It is based on an idea that it combines as a means for producing a piezo-electric oscillating angular-velocity meter and can do. The configuration of vibrator was made into the cantilever or doubly-supported beam configuration supported by the base, while forming vibrator on the silicon substrate which serves as a base according to a silicon processing process and forming on it the thin film which consists of piezo-electricity and an electrostriction ingredient by the silicon processing process and the approach of adjusting.

[0006]

[Function] If the alternating current electric field of the frequency near the resonance frequency of the transverse oscillation of the vibrator of a cantilever type or a doubly-supported-beam type made into the thin film which consists of piezo-electricity and an electrostriction ingredient with silicon are impressed, natural frequency will be excited by vibrator according to a piezoelectric inverse effect. If a revolution takes place to the surroundings of the shaft of a beam in this phase, Coriolis force will occur in the direction vertical to the shaft orientations of a beam, and the both directions of the oscillating direction. This force is made to deform a beam into the oscillation and perpendicularly it happens by actuation electric field, and if the induction charge produced according to the piezo-electric forward effectiveness in another piezo-electricity and electrostriction thin film fixed to vibrator by this is detected, it can estimate the angular rate of rotation with the relation shown below.

[0007]

Fc=2m [v-omega] ... (1)

Here, for Fc, Coriolis force and m are [the velocity of vibration of vibrator and omega of the mass of vibrator and v] the angular rates of rotation. the thin film which consists of piezo-electricity and an electrostriction ingredient formed through other layers, such as direct or an electrode, on vibrator is formed by the silicon processing process and the approach of adjusting -- desirable -- for example, sputtering, vacuum deposition, EB vacuum evaporationo, and MOCVD -- it is formed of vacuum thin film coating technology, such as law.

[0008] Since it is a two-dimensional processing process fundamentally, especially in order to be cheap, as for the silicon processing process represented by photolithography and anisotropy chemical etching, it is desirable to consider as the configuration of vibrator processsible two-dimensional, and it is desirable to form in a silicon wafer side at parallel the thin film which for that consists of piezo-electricity and an electrostriction ingredient, and the electrode for taking out the piezo-electric effect from this thin film further.

[0009] In addition to the piezo-electric signal resulting from Coriolis force, the output to which the piezo-electric signal accompanying an oscillation of a beam was added is obtained from the electrode for detection. If Coriolis force is added, a beam will bend to the oscillating direction and a perpendicular direction, and a tensile stress will join [compressive stress] the symmetry to the longitudinal plane of symmetry of a beam at the side else at one side. As for the piezo-electric signal resulting from the Coriolis force obtained from two electrodes, a sign will be [an absolute value] equal opposing if the electrode for detection is arranged to the symmetry here at the medial axis of a beam. Since the piezo-electric signals based on an oscillation of a beam are two electrodes and become equal, if the difference of the output obtained from two electrodes is taken, only the signal resulting from Coriolis force can be acquired.

[0010] in order to simplify a component further, it is desirable to attach the electrode divided to one piezo-electricity and an electrostriction thin film rather than to to form independently the object for actuation, and the piezo-electricity for each detection and an electrostriction thin film, and to use the object for actuation and other parts as an object for detection for membranous [some].

[0011]

[Example] An example explains this invention further below at a detail. Drawing 11 shows one example of the piezo-electric oscillating angular-velocity meter based on this invention. The cantilever type vibrator (1) made with silicon is being fixed to the base (2) of the same silicon. a silicon nitride film (3) forms in a silicon top face -- having -- a this top -- a platinum lower electrode (4) titanic-acid zirconic acid lead (PZT) piezoelectric film (5) -- the platinum up electrode (6) is formed further. Drawing 12 is drawing which cut in respect of the platinum lower electrode, and looked at the component from the upper part.

[0012] The lower electrode is divided into the object for actuation (9), and three parts for detection (8 a, b). If an up electrode is used as a common gland and the electric field of the frequency near the cantilever resonant frequency of vibrator are impressed to the electrode for actuation, a cantilever oscillation will be excited in the direction shown all over [V] drawing by oscillation of a PZT piezoelectric film. While vibrator is moving in the direction of V at a rate V, according to the formula (1) previously shown that the angular rate of rotation omega joins the shaft orientations of a cantilever around this shaft, Coriolis force Fc works to vibrator. This force sags vibrator to the direction and perpendicular direction of an oscillation. When the force is added in the direction shown in drawing 12 , compressive stress acts on the electrode 8a side for detection, and a tensile stress acts on the electrode 8b side for detection. If the electrical potential difference detected between va, electrode 8b for detection, and a gland in the electrical potential difference detected between electrode 8a for detection and a gland is set to vb, it will be detected in the form where the signal with which va and vb originate in a cantilever oscillation in addition to the signal accompanying Coriolis force was compounded. Since signs differ by va and vb, if both difference va-vb is taken, the signal resulting from a cantilever oscillation will be offset, and the signal by Coriolis force can read only the signal by Coriolis force.

[0013] One example of the production process of the piezo-electric oscillating angular-velocity meter shown in drawing 2 at drawing 1 is shown. The Pt/Ti film which serves as a lower electrode with a CVD method in a silicon nitride film at one side after film production is produced by the spatter to both sides of Si (110) wafer (2-1). Next, the trichotomy electrode pattern used as the electrode for actuation and detection and the resist pattern corresponding to the lead section and the bonding area for wiring which are needed for these and coincidence are formed with photolithography (2-2). Furthermore, it removes until it reaches the silicon nitride film of a substrate except for the part covered by reactant etching by the resist pattern in the Pt/Ti film (2-3). And except for the part used as an opening required to form a cantilever, and the part which hits each boundary between components, a resist is formed with photolithography (2-4). The silicon nitride corresponding to an opening part is similarly removed by reactant etching (2-5). It leaves the part which hits an opening similarly to a rear face, REJISUTOPATA - N is formed (2-6), and reactant etching removes a silicon nitride film into this part (2-7). Thus, if a potassium hydroxide performs anisotropic etching to the processed whole silicon wafer, etching will progress from a part without the silicon nitride used as the protective coat to etching, and a cantilever configuration will be acquired (2-8). Next, a PZT thin film is formed in the part centering on a cantilever by the spatter (2-9). Finally an up electrode is formed by mask vacuum evaporationo, and a component is completed (2-10). If the suitable actuation power source and suitable detector for this component are connected, it can be used as a piezo-electric oscillating angular-velocity meter.

[0014] It is the same as that of a cantilever type also with a production process and the principle of operation fundamentally also about a doubly-supported-beam type piezo-electricity oscillating angular-velocity meter.

[0015]

[Effect of the Invention] As above, if this invention is followed, a very small cheap moreover oscillating piezo-electric angular-velocity meter can be acquired. A simple substance not only uses, but the piezo-electric oscillating angular-velocity meter of this invention can be included in small systems, such as a micro machine and a micro robot.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is one example of the piezo-electric oscillating angular-velocity meter based on this invention.

[Drawing 2] It is an example of the process for producing the piezo-electric oscillating angular-velocity meter shown in drawing 1 .

[Drawing 3] It is the conceptual diagram of the conventional piezo-electric oscillating angular-velocity meter.

[Drawing 4] It is the conceptual diagram of the conventional piezo-electric oscillating angular-velocity meter.

[Description of Notations]

1 Vibrator

2 Base

3 Silicon Nitride

4 Lower Electrode

5 PZT Film

6 Up Electrode

7 Silicon Nitride Film (Base)

8 Electrode for Detection

9 Electrode for Actuation

10 Resist

11 Slot for Cutting

12 PZT

13 Metal Vibrator

14 Piezo-electric Ceramic Plate for Actuation

15 Piezo-electric Ceramic Plate for Detection

16 Piezo-electric Ceramic Bimorph for Actuation

17 Piezo-electric Ceramic Bimorph for Detection